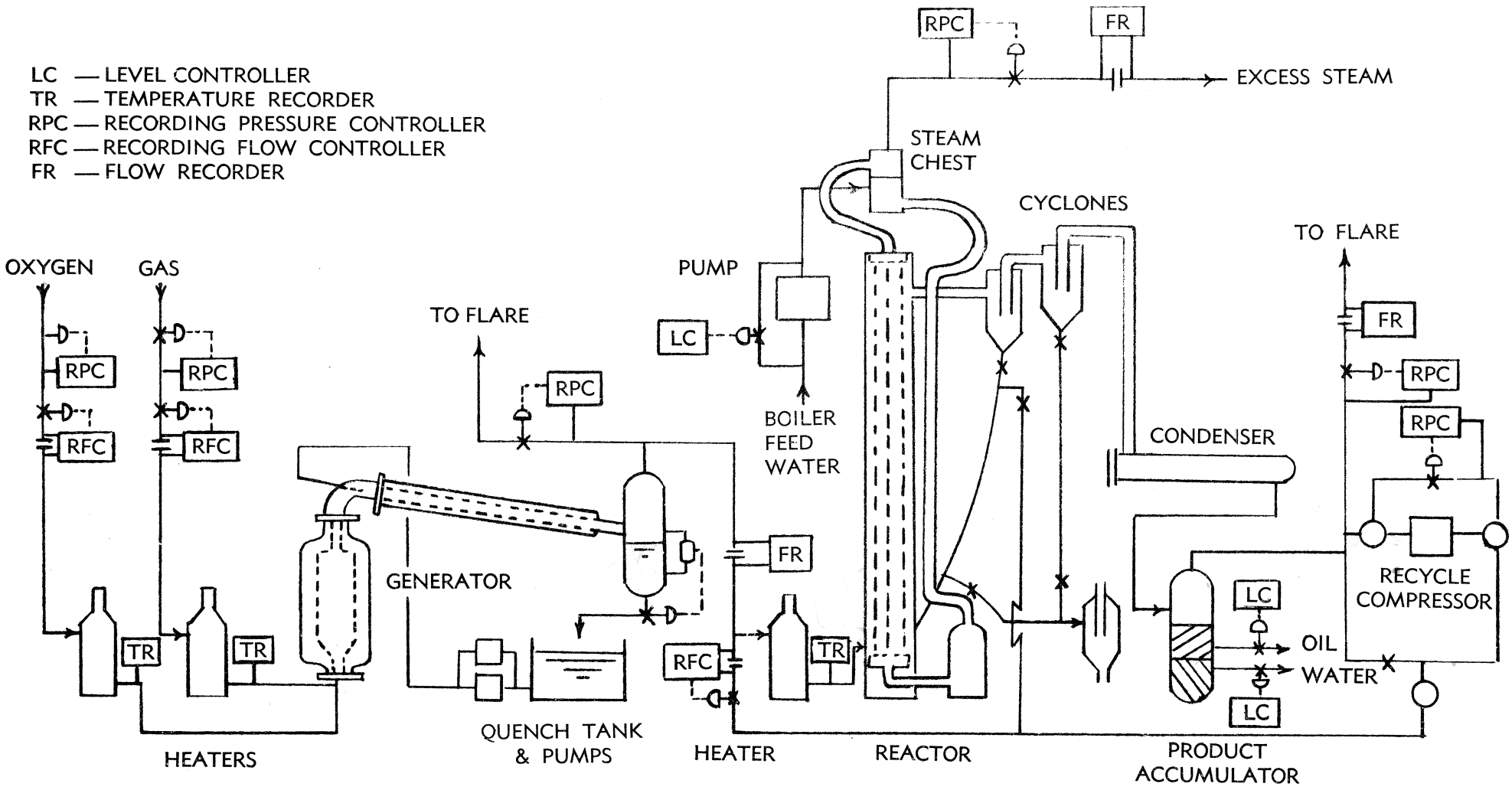
II. EQUIPMENT AND METHOD OF OPERATION

A. GENERATOR SYSTEM

The Montebello synthesis system consists of a generator in which natural gas and oxygen are reacted to produce a mixture of hydrogen and carbon monoxide, and a synthesis reactor where these gases are combined to produce hydrocarbons, water and carbon dioxide.

The generator is a vertical, internally insulated, cylindrical vessel 10" x 34" in cylindrical section, which is fitted with a conical burner block at the bottom which expands from 3" to 10" in diameter in a vertical distance of 12". The internal volume of the generator is 2.0 cu. ft. Preheated natural gas and oxygen are separately fed to the burner which is placed at the apex of the conical burner block. The burner consists of concentric 1" IPS and 3/4" O.D. tubing 18-8 and inconel tubes which carry the gas and oxygen respectively. Both tubes are swedged at the burner end to produce an annular gas jet which impinges on a central oxygen jet at the apex of the



FLOW DIAGRAM OF GAS FIRED GENERATOR
AND MONTEBELLO REACTOR

burner block. A 1/8" IPS water cooling tube is wrapped around the burner tip to prevent overheating. Generator product gas is quenched with a water spray in a water jacketed transfer line which leads to an accumulator where the quench water is separated and discharged to a quench tank for recirculation. Gas from the accumulator is reheated in a steam jacketed transfer line where any entrained moisture is evaporated, and the dried gas is then sent to the synthesis system. In Run 25 no quench water was used, and the generator effluent gases were cooled only by the jacketed transfer line.

B. SYNTHESIS SYSTEM

The synthesis system consists of a vertical, cylindrical reactor constructed of 10" extra heavy pipe 30 ft. long which is fitted with three 2" extra heavy steam tubes which extend throughout the full length of the reactor. These tubes are connected with a steam drum at the top and a mud drum at the bottom, the boiler circuit being completed by an external downcommer. Fresh feed and recycle gas are combined, preheated and fed to the bottom of the reactor. Effluent gases leaving the top of the reactor pass through two cyclone separators to remove entrained catalyst, and then flow to a condenser and a separator where water, oil, and gas are separated. Oil and water are discharged separately to storage, while the gas is compressed and recycled, sufficient gas being released to the flare to maintain the desired reactor pressure.

C. DESCRIPTION OF OPERATION

In Runs 17 and 18 none of the catalyst fines, collected from the reactor effluent in two cyclones, was returned to the

reactor. In Run 21, both new catalyst and some overhead c atalyst were charged to the reactor, but there were no appreciable changes in yields. There did not appear to be any induction period in these runs and the conversion levels remained consistently low. This may have been due to the permanent removal of catalyst fines from the reactor.

In Runs 22 through 26, provision was made so that, periodically, the catalyst fines from the first cyclone either could be returned to the bottom of the reactor, or could be blown out of the system as was done in Runs 17 to 21. The second cyclone system remained unchanged.

In Runs 27 and 28, the first cyclone system was changed back to the same type as used previous to Run 22.

Run 22 was started with 255 pounds of reduced catalyst in the reactor and a bottom bed temperature of 655°F. For the first two days the conversion remained low; and in an attempt to raise the conversion level, the bed temperatures were raised slowly, reaching 710 - 720°F. for eight hours on the third day of operation. At this time the particle size distribution of the catalyst changed abruptly, the 80-plus micron fraction dropping from 60 - 70 per cent of the charge to 35 per cent; at the same time the conversion and yields increased. These high conversions and yields were maintained with an average bed temperature of 620 - 645°F. for the next seven days, during which fresh reduced catalyst was added from time to time to maintain the catalyst inventory in the reactor and keep the conversion at the desired level. At the end of this week of high-conversion operation the supply of freshly reduced catalyst had been exhausted and it was,

therefore, impossible to maintain the catalyst inventory and activity by adding fresh catalyst. Some used catalyst, which had been blown down from the cyclones during the first part of the run, was added; but the yields and conversions declined steadily. The carry-over of catalyst to the cyclones increased steadily, and although the contraction could be brought back to its previous high value for a short time by recharging used catalyst, the catalyst carried out of the reactor so rapidly that operation became steadily more difficult. After three days of declining yields, the unit was shut down.

Run 23 was an attempt to duplicate Run 22, essentially the only difference being a higher linear inlet velocity, 1.5 - 1.6 feet per second as against 1.0 feet per second for Run 22. The catalyst carry-over from the reactor was several times as great in this run as in Run 22.

An attempt to condition the catalyst as in Run 22 was made by slowly raising the bottom bed temperature to 700 - 720°F. but the conversions remained low and the desired activity was never achieved. Because of mechanical difficulties, this run lasted only 77 hours.

In Run 24 an attempt was made to approximate Beacon Laboratory's start-up procedure, in which the catalyst is treated with synthesis gas at atmospheric pressure and the bed temperature is increased gradually for an extended period. Starting with 302 pounds of catalyst in the reactor, the catalyst was treated with synthesis gas at 100 psi pressure, and the bed temperature was steadily raised from 480°F. to 612°F. over a period of 17 hours. Then over a 24-hour period the pressure was raised slowly,

and the reactor was lined out at 300 psi pressure and 700°F. with a 1/1 recycle ratio. The conversions and yields were low throughout this run; raising the recycle ratio to 1.5, raising the bed temperatures as high as 720°F., and removing 100 pounds of catalyst from the reactor and recharging 100 pounds of catalyst from Run 23 all failed to improve the conversion. Although the catalyst became increasingly finer as the run progressed, the conversions and yields never approached those of Run 22. The run ended because of mechanical difficulties.

Run 25 was started by reducing the catalyst with hydrogen in the usual manner, but the catalyst was not allowed to come in contact with natural gas before cutting in the fresh feed. In all previous runs, natural gas had been used to maintain pressure on the system before introducing the synthesis gas. The effluent from the generator was cooled by a line-cooler, rather than by a direct quench, to eliminate the possibility of poisoning of the catalyst with the quench water. The fresh feed was cut into the hydrogen atmosphere in the reactor at 200 psi pressure, and the pressure on the system was raised to 400 pounds during the first 24 hours of operation. The conversion level increased during the first 24 hours, but steadily declined thereafter.

In Run 26 the synthesis gas was introduced into the reactor while the reduced catalyst was under hydrogen pressure of 200 psi. The pressure was raised to 400 psi within an hour. No quench water was used at first to cool the generator gas; but after ten hours of operation, it was necessary to reduce the pressure on the system to 300 psi in order to cut in quench water,

because the generator effluent gas was not being cooled sufficiently by the water-jacketed transfer line. These conditions were maintained until the run was terminated by mechanical failure.

The conditions for Run 27 and 28 were similar to those for Run 26, except that the reactor pressure was maintained at 400 psi. The catalyst charged in Runs 27 and 28 was from the same batch reduced for Run 26. Run 28 was in reality a continuation of Run 27 since the used catalyst was not removed from the reactor at the end of Run 27.